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STEP 9.2110

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TITLE: Capacitance of a varicap and the distribution of ionized impurities in its p-n junction

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TEXT: A semiconductor junction, in which the concentration of ionized impurities varies along the axis perpendicular to the plane of the junction, is considered. The structure of the space charge in the region of the p-n junction is illustrated in Fig.1, where the coordinates x_1 and x_2 correspond to the boundaries of the depletion layer. The differential capacitance of the junction is expressed by a formula similar to that of a parallel plate capacitor, i.e.

$$C = \frac{\varepsilon S}{4\pi (x_2 - x_1)} \qquad (1),$$

where ε is the permittivity of the semiconductor material and S is the area of the p-n junction. The problem consists of

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finding the conditions under which the capacitance of the junction (varicap) is a prescribed function of the voltage U applied to it. The function C(U) should be monotonically decreasing since with increasing external voltage the depletion layer is increased and the capacitance of the junction reduced. It is assumed that the distribution $\rho(x_2)$ for one of the regions of the p-n junction is known. This is necessary in order to be able to determine the distribution $\rho(x_1)$ for the other region so that the required function C(U) is achieved. It is found under these conditions that:

$$\rho(x_1) = \frac{\rho(x_2)}{1 + \frac{\varepsilon S}{4\pi C^2(x_2)} \cdot \frac{dC}{dx_2}} \qquad (9).$$

This expression can be used for determining $\rho(x_1)$ for a given C(U) and $\rho(x_2)$. In general, the required C(U) is in the form:

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$$C = C_o \left(\frac{\varphi_K}{U + \varphi_K} \right)^n \qquad (13),$$

where C_o is the initial capacitance and φ_K is the contact potential. For this C(U) Eq. (9) is used to evaluate $\varrho(x_1)$ when $\varrho(x_2) = \varrho x_2^m$ and $\varrho'(x_2) = \varrho$. Eq. (9) can be used for approximate calculation of the acceptor (or donor) distribution for a given distribution of donors (or acceptors) and a given experimental graph showing the functional dependence of the capacitance on the applied voltage U. There are 6 figures.

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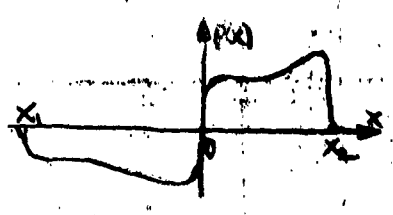
Fig. 1:



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